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EXPERIMENTS ON CONDENSATION IN STEAM HEATED BUILDING

BY

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

James Franklin McIntire

ENTITLED EXPERIMENTS ON CONDENSATION IN STEAM-HEATED BUILDING

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Bachelor of Science in Architecture

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EXPERIMENTS ON CONDENSATION IN STEAM HEATED BUILDINGS.

LOCATION OF SYSTEM TESTED.

Engineering Hall, in which the tests for this Thesis were conducted, is one of the group of University of Illinois buildings, located at Urbana, Illinois.

DESCRIPTION OF BUILDING.

The building stands on practically level ground, the surrounding buildings affording little wind protection. The building is a well constructed brick and stone structure, having a sub-basement which is used for heating and wiring purposes only, a basement, three stories, and attic.

The basement, which has stone outside walls thirty inches thick in the main mass and twenty six inch walls in the east and west wings, is above grade level. The outside brick walls of the building which begin on a line with the window sills of the first floor are twenty six inches thick in the central mass, and twenty two inches in the wings.

The third story has a large exposed wall surface due to the fact that there is no attic over the wings of the building, and here the wall formed by the roof is treated as exposed wall surface. The roof sheathing is covered with mineral wool and slate. The skylights are double but have been treated in each case as straight glass surface.

DESCRIPTION OF HEATING SYSTEM.

The building is heated by a one pipe, overhead feed system of steam heat. The steam is furnished from a Central Heating Plant and is delivered to the building under high pressure. The main

steam supply enters the east end of the sub-basement from the tunnel. The steam pressure is reduced by means of a "Davis" pressure regulator set at about four pounds pressure.

An eight inch riser carries the steam to the attic where it is supplied to "three 4 1/2" feed^s running north and south east and west the entire length of the building. From these mains three and one half inch branches are run to feed two inch drops.

The riser, mains and supplies in attic are covered with magnesia covering. The drops and radiator connections are exposed and have been considered as radiating surface in these experiments.

The condensation is collected into two three inch return pipes in sub-basement, and is trapped out by two "Davis" traps through pipes in the tunnel.

When the system of heating was first installed the building was heated partly by direct and partly by direct-indirect radiation. The direct-indirect was placed in some of the rooms on the first and second floors where ventilation was most necessary. The radiators were set in recesses under the window sills and the heat was admitted to the room through vertical registers. A cold air duct leading from a cast iron perforated lintel of the window below furnished the fresh air supply. The method employed in setting the direct-indirect radiator is shown in Figure 1.

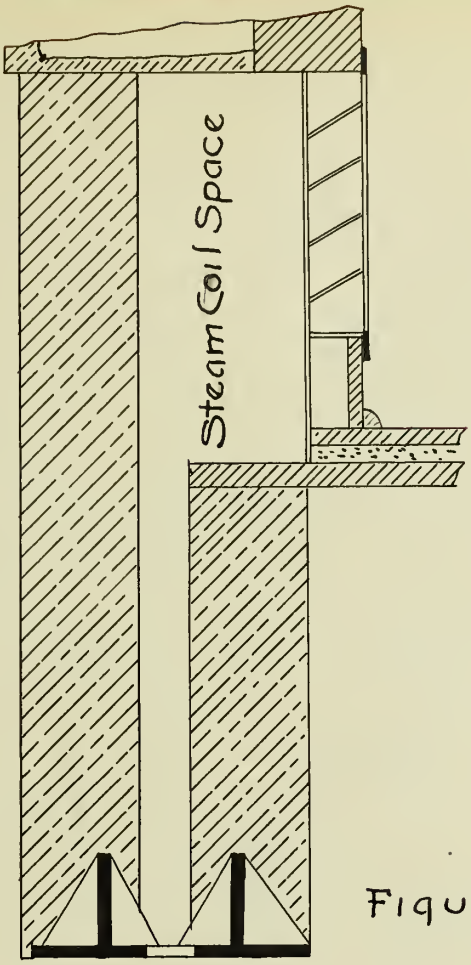


Figure No. 1.

Each room where direct-indirect radiation was installed was provided with a vent flue to aid the circulation of air, and it was originally intended to force the circulation of air in some of these rooms by use of an exhaust fan in the sub-basement. As this fan was never installed and the radiation was inadequate, the fresh air inlets were closed up and the registers and frames were removed from the front of the recesses, making the radiation throughout the building direct.

All direct-indirect radiators are wrought iron, having four pipes to the row, and all other radiators are cast iron, two column, Ideal pattern. The wrought iron radiation has been figured on the same basis as the cast iron radiation in this experiment, as the difference in setting will equalize the efficiency.

Wrought iron radiation is painted with aluminum bronze and all other radiators and exposed pipes are painted with maroon Japan.

Just before the test was run all the air valves were inspected and placed in good working order.

OBJECT OF TEST.

The object of this experiment was to determine the amount of condensation in the radiation per square foot per hour per degree difference between steam and room temperature.

DESCRIPTION OF TEST.

The test was run from seven A. M. until six P. M. on a day having a wide range of outside temperature. This temperature was recorded every hour.

Thermometers were placed in each room and corridor throughout the building and temperatures were recorded every two hours. The condensation was weighed, the weight, time and temperature being recorded. A meter was placed in a by pass connection in the return main, and the condensation was discharged into tanks placed on platform scales. The meter readings were recorded and the water was weighed in the tanks as a check. An error was found in the meter readings, so the meter was abandoned and the exact amount of return water was secured by weighing.

The return water was handled as follows,--Two tanks, each having a capacity of about seven hundred pounds of water were used. Each tank was placed on a pair of platform scales. A cold water supply was run to each tank. A connection was made to the return main emptying into one tank with a bypass to the other tank.

One hundred pounds of cold water were run into each tank before it was filled with condensation to prevent evaporation. The weight, time and temperature were recorded. The weight minus the weight of the tank and cold water gave the total amount of water flowing through the return mains.

As a certain amount of estranged water is carried in the supply mains with the stream, a separating calorimeter was placed on the main on the low pressure side of the regulator. Ten minute readings were taken. The percentage of moisture in the steam was calculated and this quantity was subtracted from the quantity of water weighed at the return. The remainder gave the total condensation in the heating system.

DATA.

The cubic contents, exposed wall surface and glass area were calculated and recorded for each room and corridor. The amount of radiating surface in each room and corridor, including the cast iron and wrought iron radiators and exposed pipe, was recorded. These results are given in tables No. 1, 2, 3 & 4. These tables also give the temperature in each room and corridor, the difference between the inside and outside temperatures the time of observations, and the average difference in temperature for periods of two hours.

Table No. 5 gives a summation of the quantities in tables Nos. 1, 2, 3, & 4, as well as totals and averages for the whole building.

CALCULATIONS.

The following summary is from table No. 5.

Total cubic contents--------746710 cubic feet.

Total exposed wall--------43558 square feet.

" glass surface--------7288 " " .

" radiating surface---10714 " " .

" condensation 7 to 5-32508 pounds.

Condensation per square foot of radiating surface per hour--.3034 pounds. The average temperature of the condensation was 209 degrees Fahrenheit. As the condensation per hour equals 3250 pounds and one pound of water at 209 degrees contains 209 B. T. U. the condensation per hour contains 679250 B. T. U. The B. T. U. in the steam supply equals 3,838,250, since there are 1181 B. T. U. in the steam at 222° Fahr. which is the average steam temperature during the test.

The total B. T. U. given off by the radiation is equal to the difference between the total B. T. U. in the steam supplied per hour, or,

3,838,250-679,250=3,159,000 B. T. U. per hour.

The average difference in temperature between the inside air and steam during the test was 150.°6 Fahr. The B. T. U. per hour per square foot of radiation per degree difference in temperature between steam and inside air was

295 ÷ 150.6 = 1.9 B. T. U.

Results from Carpenter's Rule.

By Carpenter's Rule

$H = (.02\ N\ C + 1/4\ W + G)\ T$

where .02 is the cubic feet of air that will absorb one heat unit in being warmed one degree. N is the number of changes of air per hour.

C is the cubic contents.

W is the exposed wall surface in sq. ft.

G is the glass surface in sq. ft.

T is the difference in temperature between the inside and outside air and,

H is heat-units required to supply the loss of heat through glass, exposed wall and ventilation.

Assuming three changes of air per hour this formula becomes

$H = (.06 \times 746,710 + \frac{43588}{4} + 7238)\ 51.$

$H = 3,198,783$ B. T. U.

which is in excess of the number of B. T. U. per hour obtained from the test by the difference between

$3,198,783 - 3,159,000 = 39,783$ B. T. U.

By using Carpenter's Formula and taking as a factor for proportioning radiation found in table, page 236, Carpenter's Heating and Ventilating Buildings, the value .21

$R = (.02\ N\ C + 1/4\ W + G).21$

The radiation in the building being 10714 square feet, the equation becomes,

$10714 = (.02\ N \times 746,710 + \frac{43588}{4} + 7238).21$

solving for N the number of changes of air per hour is equal to 2.2 changes.

In the same way assuming two changes of air and solving for the factor for proportioning radiation,

$R = 48046F = 10714$

$F = .223$ for a steam pressure of 3 1/2 pounds and difference in temperature of 51 degrees Fahr.

Results from Mill's Rule.

From Mill's Rule for figuring radiation, which provides for one change of air per hour, and using the quantities in table No. 5 of this thesis,

$G/200 + W/20 + G/2 = R$,

becomes

$$\frac{746710}{200} + \frac{43558}{20} + \frac{7233}{2} = R.$$

R = 9966 Square feet of radiation which is less than the building contains by 748 square feet.

Results from Model Heating Company's Rule.

The radiation required for the building as figured by a rule published by the Model Heating Company is,

$[(W/10 + G)\ 75 + C] .0055 = R.$

(11643.3 x 75 + 746710) .0055 = 8910 square feet for one change of air per hour.

Results from Willett's Rule.

Willett's Rule for proportioning direct radiation is expressed by the following formula:

$R = 0.43\ G + 0.03\ W + 0.002\ C$

which becomes,

R = 3071 + 3484.3 + 1941.4 = 3497 square feet.

Results from Baldwin's Rule.

From Baldwin's Formula,

$E = G + W/10$

where E is the glass equivalent surface.

$R = 3/4\ E.$

From table No. 5.

E = 7233 + 4355 = 11,643

R = 3/4 (11,043) = 8757 square feet.

RESULTS FROM TEST.

From table No. 5 the total cubic contents = 74671 cubic feet. The total radiation = 10714 square feet, or one square foot of radiating surface heats 70 cubic feet of air per change of air per hour.

Since from the test it was found that 295 B. T. U. were given off per square foot per hour, and as one square foot of radiation heats 210 cubic feet of air per hour, assuming three changes, the units of heat required per square foot per hour of heating surface to heat one cubic foot of air at a difference in temperature of 51 degrees Fahr. is equal to 295 ÷ 210 = 1.4 B. T. U.

One horse power is equivalent to the evaporation of 34.5 pounds of water at atmospheric pressure, then as the condensation from

7 to 9 A. M.	equaled	6703	the	H. P.	used	was	194.29
9 to 11 "	"	6615	"	"	"	"	191.74
11 to 1 P. M.	"	6619	"	"	"	"	191.35
1 to 3 "	"	6232	"	"	"	"	132.09
3 to 5 "	"	6289	"	"	"	"	132.29

Total H. P. used from 7 A. M. to 5 P. M. = 942.26

The H. P. used per hour = 94.226 or, one H. P. supplied,

10714 ÷ 94,226 = 113 square feet of radiation.

Carpenter gives one horse power as equivalent to 100 square feet of direct steam radiation, with sufficient allowance to meet ordinary losses.

By Carpenter's Rule the total B. T. U. required for the

building on the basis of three changes of air per hour is 3,198,733 B. T. U. per hour, and as 33,327 heat units equal one horse power, the calculated horse power would be 3,159,000 ÷ 33,327 = 95.98 horse power per hour.

SUMMARY OF RESULTS.

The data for this experiment was obtained from a test run under ordinary working conditions, in a building of common construction, and on a heating system giving entire satisfaction, and for this reason the writer believes the results are practical.

The results of the test have been compared with the experience of various heating engineers and have been found to agree very closely with their results.

The condensation per square foot per hour as calculated from the test was .3034 pounds which is a mean of the results given by J. H. Mills in his book, Warming and Ventilation of Buildings, and the work of Prof. J. H. Kinealy, "Formulas and Tables of Heating." The value of 1.9 B. T. U. per hour per square foot per degree difference between steam and inside temperature is a little high due to heat losses from the return mains and vent flue coils which have not been considered here.

As calculated from Carpenter's Rule the air was changed a little over twice per hour during the test which indicates that for good construction two changes is a safe estimate.

The following table gives the radiating surface installed in Engineering Hall and the amount required as calculated by different rules:

Carpenter	9,609	square	feet.
Mills	9,900	"	"
Model Heating Co.	8,910	"	"
Willetts	8,476	"	"
Monroe	8,497	"	"
Baldwin	8,757	"	"
Amount installed	10,714	"	"
Direct plus $\frac{3}{4}$ direct-indirect	9,925	"	"

The amount of radiating surface installed is more than required to heat the building due to the fact that where direct-indirect radiation was installed the quantity was increased 25 percent, as seen in table the direct plus 3/4 direct indirect gives a value agreeing with the amount required by rule.

By calculation 1.4 B. T. U. are required per square foot per hour to heat one cubic foot of air at a difference in temperature between the external and internal air of 51 degree Fahr. and this result corresponds to the value given in table in"Manual of Heating and Ventilation," by F. Schumann.

Table No. 6 of this thesis gives a method for figuring radiation based upon Carpenter's Formula, assuming two changes of air per hour and a factor of .25 for proportioning radiation.

Divide the cubic contents by 100 and add the value found in the table for the calculated glass and exposed wall surface.

The formula may be expressed by the equation

$R = .01\ C + K$

where C = cubic contents and K equals value found in table.

r. from 7 AM. to 6 P.M.

Inside Temp	Dif. in Temp	Time P.M.	Inside Temp	Dif. in Temp	Time P.M.	Inside Temp	Dif. in Temp
		3:30			5:30		
75.6	48.1		76	49		76	50
72.4	44.9	3:31	72.4	45.4	5:31	73.4	47.4
75.6	48.1		72.4	45.4		74.8	48.8
65.2	37.7	3:32	64	37	5:32	62.6	36.6
68.4	40.9		68	41		66.2	40.2
68.8	41.3	3:33	68.8	41.8	5:33	69.8	43.8
69.8	42.3		70.6	43.8		70.6	44.6
73.8	46.3	3:34	73	46	5:34	75.2	49.2
75.6	48.1		76	46		77	51
68.8	41.3	3:35	69.8	42.8	5:35	70.6	44.6
74.2	46.7		76	49		71.6	45.6
		3:36			5:36		
74.8	47.3		75.2	48.2		75.2	49.2
72.8	45.3	3:37	70.2	43.2	5:37	71.6	45.6
71.2	43.7		73.4	46.4		75.2	49.2
73.	46.5	3:38	73.8	46.8	5:38	74.2	48.2
72	45.5		72	45.		75.5	49.5
69.5	42	3:39	72	45	5:39	75.5	49.5
69.5	42	3:40	72	45	5:40	75.5	49.5
71.2	42.7		72	45		72	46
70.1	42.4		72	45		74.2	49

Table No. 1

No of Room	Name of Room	Air Space Cu Ft	Exposed Wall Sq Ft	Glass Surface Sq Ft	Square Feet of Radiation: C I Radiators	Exposed Pipes	Total Direct	Temperatures in Degrees Fahr. from 7 AM to 6 PM: Time AM	Inside Temp	Dif in Temp	Time AM	Inside Temp	Dif in Temp	Time AM	Inside Temp	Dif in Temp	Time P.M.	Inside Temp	Dif in Temp	Time P.M.	Inside Temp	Dif in Temp	Time P.M.	Inside Temp	Dif in Temp
00	Technograph	2244	132					7:30			9:30			11:30			1:30			3:30			5:30		
01	Recitation Rm	6292	352	63	76.7	15	91.7		68	55		70.6	51.1		73.4	48.9		75.6	48.1		76	49		76	50
02	Optics	6435	352	63	76.7	15	91.7	7:31	68	55	9:31	68	48.5	11:31	71.2	46.7	1:31	72.4	44.9	3:31	72.4	45.4	5:31	73.4	47.4
03	Study	3454	209	63	53.3	7	60.3		69.4	56.4		72.4	52.9		73.4	48.9		75.6	48.1		72.4	45.4		74.8	48.8
04	Study	3443	209	63	53.3	7	60.3	7:32	59	46	9:32	59	39.5	11:32	63.6	39.1	1:32	65.2	37.7	3:32	64	37	5:32	62.6	36.6
05	Instrument Rm	9042	660	168	146.7	7	153.7		59	46		62.2	42.7		66.2	41.7		68.4	40.9		68	41		66.2	40.2
06	Recitation Rm	4422	286	56	60	17	77	7:33	65.8	52.8	9:33	65.4	45.9	11:33	68	43.5	1:33	68.8	41.3	3:33	68.8	41.8	5:33	64.8	43.8
08	Military Office	4422	440	112	93.3	23	116.3		64.4	51.4		65	45.9		67.6	43.1		69.8	42.3		70.6	43.8		70.6	44.6
09	Recitation Rm	3696	374	112	80	18	98	7:34	71.2	58.2	9:34	71.6	52.1	11:34	72.6	47.1	1:34	73.8	46.3	3:34	73	46	5:34	75.2	49.2
09A	Study	3696	330	56	60	6	66		69.4	56.4		72.4	52.4		73.4	48.9		75.6	48.1		76	46		77	51
11	Instrument Rm	7392	440	112	100	28	128	7:35	66.2	53.2	9:35	66.8	47.3	11:35	68	43.5	1:35	68.8	41.3	3:35	69.2	42.8	5:35	70.6	44.6
12	Drawing Rm	7414	704	168	140	20	160		58	45		60	40.5		66.2	41.7		74.2	46.7		76	49		71.6	45.6
13	C.E. Repair Shop	3894	66	63				7:36		56.4	9:36			11:36			1:36			3:36			5:36		
13	Toilet	3894	100	17	36.3	15	151.3		69.4	56.4		71.6	52.1		73.4	48.9		74.8	47.3		75.2	48.2		75.2	49.2
	Janitors Rm	2032	240	63	40	9	49	7:37	64.4	51.4	9:37	65.2	45.7	11:37	68	43.5	1:37	72.8	45.3	3:37	70.2	43.2	5:37	71.6	45.6
14	Shop	7414	440	112	106.7	24	130.7		64.4	51.4		65.2	45.7		68	43.5		71.2	43.7		73.4	46.4		75.2	49.2
16	Toilet	1584	100	17	20	7	27	7:38	64.8	51.8	9:38	70.6	51.1	11:38	72	47.5	1:38	73	46.5	3:38	73.8	46.8	5:38	74.2	46.2
17	Phys. Batteries	2750	165	42	40	20	60		67.7	54.7		68	48.5		69	44.5		72	45.5		72	45		75.5	49.5
18	Phys Test	2640	165	42	36.3	7	43.3	7:39	67.7	54.7	9:39	68	48.5	11:39	69.5	45	1:39	69.5	42	3:39	72	45	5:39	75.5	49.5
19-124	Phys. Test	35247	2255	633	506.6	71	577.6	7:40	67.7	54.7	9:40	66.2	46.7	11:40	69	44.5	1:40	69.5	42	3:40	72	45	5:40	75.5	49.5
	Corridor	27512	442	105	200	55.5	255.5		65.2	52.2		66.2	47.5		67.6	43.1		71.2	42.7		72	45		72	46
	Total or Average	163776	7690	1354	2093	270.5	2364.5		65.7	52.7		67	47.5		68.9	44.4		70.1	42.4		72	45		74.2	49

Table No. 1

Fahr. from 7 A.M. to 6 P.M.

Time A.M.	Inside Temp	Dif. in Temp	Time A.M.	Inside Temp	Dif. in Temp	Time A.M.	Inside Temp	Dif. in Temp
1:19	77	50	3:19	76.6	49.6	5:19	75.2	49.2
	72.4	45.4		71.2	44.2		78	52
1:20	78.8	51.8	3:20	77	50	5:20	75.2	49.2
	80	53		79	52		78	52
1:21	79.6	52.6	3:21	77.4	50.4	5:21	77	51
	72.2	45.2		73	46.2		72.4	46.4
1:22	82.8	55.8	3:22	71.6	44.6	5:22	82.4	56.4
	76	49		77	50		77	51
1:23	69.8	42.8	3:23	72.4	45.4	5:23	70.6	44.6
	70.2	43.2		71.6	44.6		70.6	44.6
1:24	71.6	44.6	3:24	76.6	49.6	5:24	71.6	45.6
	65.8	38.8		67.6	39.6		68	42
1:25	72.9	52.2	3:25	80.6	53.6	5:25	80.6	54.6
	71.6	44.6		73.4	46.4		74.2	48.2
1:26	77.2	50.6	3:26	77	50	5:26	77.8	51.8
	74.8	47.8		75.6	48.6		76	50
1:27	72.4	45.4	3:27	74.8	47.8	5:27	75.2	49.2
	70.6	43.6		71.6	44.6		73.4	47.4
1:28	72.4	45.4	3:28	74.8	47.8	5:28	75.2	49.2
	72.4	45.4		74.8	47.8		75.2	49.2
1:29	72.4	45.4	3:29	74.8	47.8	5:29	75.2	49.2
	69.8	42.8		71.6	44.6		72.4	46.4
1:30	72	45	3:30	74.2	47.2	5:30	72.4	46.4
	73.9	46.9		74.5	47.5		74.9	48.9

Table No. 2

No of Room	Name of Room	Air Space Cu Ft	Exposed Wall Sq Ft	Glass Surface Sq Ft	Square Feet of Radiation				Temperatures in Degrees Fahr. from 7 A.M. to 6 P.M.															
					C.I Radiators	Exposed Pipes	W.I Radiators	Total Direct	Time A.M.	Inside Temp	Dif. in Temp	Time A.M.	Inside Temp	Dif. in Temp	Time A.M.	Inside Temp	Dif. in Temp	Time A.M.	Inside Temp	Dif. in Temp	Time A.M.	Inside Temp	Dif. in Temp	Time A.M.	Inside Temp	Dif. in Temp
201	Recitation Rm	7777	450	893	50	16	60	126	7:19	71.6	59.1	9:14	71.6	53.1	11:19	15.2	51.2	1:19	77	50	3:19	76.6	44.6	5:19	75.2	44.2
202	Recitation Rm	8162	450	893	50	16	60	126		61.6	49.1		64.4	45.4		70.2	46.2		72.4	45.4		71.2	44.2		78	52
203	Study	4550	300	76		16	100	116	7:20	69	56.5	9:20	73	54.5	11:20	77	53	1:20	78.8	51.8	3:20	77	50	5:20	75.2	44.2
204	Study	4564	300	76	40	10	60	110		68	55.5		70	51.5		76	52		80	53		79	52		78	52
205	Drawing Rm	11606	945	187	40	36	216	292	7:21	69.4	56.9	9:21	73.4	54.4	11:21	77.8	53.8	1:21	79.6	52.6	3:21	77.4	50.4	5:21	77	51
206	Study	4900	2175	31.2		10	60	70		67	54.5		62	47.7		64.4	45.4		72.2	45.2		73	46.2		72.4	46.4
207	Study	2436	195	62.5	56	10		66	7:22	70.6	58.1	9:22	73.4	54.4	11:22	78	54	1:22	82.8	55.8	3:22	71.6	44.6	5:22	82.4	56.4
208	Recitation Rm	7735	6262	126.2	30	26	160	216		66.2	53.7		70.2	51.7		73.8	49.8		76	49		77	50		77	51
209	Drawing Rm	9436	1342.5	342.5	80	28	160	278	7:23	68	55.5	9:23	60	44.5	11:23	69.4	45.4	1:23	69.8	42.8	3:23	72.4	45.4	5:23	70.6	44.6
210	Study	2548	163.5	63.5	60	10	60	130		65.4	52.9		58	47.3		68.8	44.8		70.2	43.2		71.6	44.6		70.6	44.6
211	Recitation Rm.	9436	193.7	93.7	50	17	120	187	7:24	69.4	56.9	9:24	68.8	50.3	11:24	69.8	45.8	1:24	71.6	44.6	3:24	76.6	44.6	5:24	71.6	45.6
212	Drawing Rm.	9436	315	93.7	76.7		160	236.7		61.2	48.7		62.6	44.1		64	40		65.8	38.8		67.6	34.6		68	42
213	CE Club	5166	120	31.2		11.5	68	79.2	7:25	75.2	62.7	9:25	77	58.5	11:25	78.8	54.8	1:25	72.4	52.2	3:25	80.6	53.6	5:25	80.6	54.6
214	Drawing Rm	9436	570	125	46.7	26	120	146		64.4	51.9		67	48.5		69.4	45.4		71.6	44.6		73.4	44.4		74.2	48.2
216	Toilet	2128	150	31.4		11	45	56	7:26	69.8	57.3	9:26	70	51.5	11:26	72.4	48.4	1:26	77.2	50.6	3:26	77	50	5:26	77.8	51.8
217	Office	3423	203	44.7		11	60	71		69.8	57.3		70.2	51.7		73.4	49.4		74.8	47.8		75.6	48.6		76	50
218	Phys Lab	3136	210	44.7		10	60	70	7:27	60.8	48.3	9:27	64.8	46.3	11:27	69.8	45.8	1:27	72.4	45.4	3:27	74.8	47.8	5:27	75.2	49.2
219	Study	5614	350	44.7		10	100	110		63.4	50.9		65.8	47.3		68.8	44.8		70.6	43.6		71.6	44.6		73.4	47.4
220	Phys Prep	5453	214	44.7		11	100	111	7:28	60.8	48.3	9:28	64.8	46.3	11:28	69.8	45.8	1:28	72.4	45.4	3:28	74.8	47.8	5:28	75.2	49.2
	Phys Prep	4998	280	80		11	100	111		60.8	48.3		64.8	46.3		69.8	45.8		72.4	45.4		74.8	47.8		75.2	49.2
	Phys Prep	5936	588	124		11	80	91	7:29	60.8	48.3	9:29	64.8	46.3	11:29	69.8	45.8	1:29	72.4	45.4	3:29	74.8	47.8	5:29	75.2	49.2
221	Phys Lecture	36408	1302	280	60	144	320	524		61.2	48.7		64.4	45.9		68	44		69.8	42.8		71.6	44.6		72.4	46.4
	Corridor	62174	600	155	140	31			7:30	65.2	52.7	9:30	65.6	47.1	11:30	69.8	45.8	1:30	72	45	3:30	74.2	47.2	5:30	72.4	46.4
	Total or Average	224224	10899	2469	1147	367.5	1619	3133.9		66	53.5		68.1	49.6		71.7	47.7		73.9	46.9		74.5	47.5		74.9	48.9

Table No. 2

ces Fahr. from 7 A.M. to 6 P.M.

No of Row	Dif. in Temp	Time P.M.	Inside Temp	Dif. in Temp	Time P.M	Inside Temp	Dif in Temp	Time P.M.	Inside Temp	Dif. in Temp
300	56.7	1:10	80	53	3:10	77	50	5:10	79	53
301	45.2		78.8	51.8		69.5	42.5		68	42
302	53.3	1:11	80.2	53.2	3:11	71.6	44.6	5:11	77	51
303	43.3		68	41		65.8	38.8		80.6	54.6
304	45.2	1:12	73	46	3:12	69.5	42.5	5:12	68	42
305	62.7		89.1	62.1		89.2	62.2		86	60
306	53.3	1:13	76.6	49.6	3:13	79.2	52.2	5:13	77	51
307	51.1		80.6	53.6		77.4	50.4		82.4	56.4
308	48.3	1:14	74.2	47.2	3:14	77	50	5:14	75.8	49.8
309	54.1		81	54		82.4	55.4		77	51
310	43.9	1:15	76	49	3:15	74.2	47.2	5:15	77	51
312	57.3		76	49		76	49		80.2	54.2
312	57.3	1:16	76	49	3:16	76	49	5:16	80.2	54.2
313	62.9		77	50		77.4	50.4		78.8	52.8
314	49.7	1:17	76.6	49.6	3:17	77.8	50.8	5:17	76	50
316	49.6		77.2	50.2		77	50		77.8	51.8
317	50.1	1:18	77	50	3:18	77	50	5.18	78.8	52.8
318	53.7		76	49		78.8	51.8		80.6	54.6
319	53.7	1:19	76	49	3:19	78.8	51.8	5:19	80.6	54.6
	58.2		74.8	47.8		75.4	48.4		76.	50
	49.63		77.2	50.2		76.31	49.31		77.84	51.84

Table No. 3

No of Room	Name of Room	Air Space Cu Ft	Exposed Wall Sq Ft	Glass Surface Sq Ft	Square Feet of Radiation: C.I. Radiators	Exposed Pipes	W.I. Radiators	Total Direct	Temperatures in Degrees Fahr from 7 AM to 6 PM: Time A.M.	Inside Temp	Dif in Temp	Time A.M.	Inside Temp	Dif in Temp	Time A.M.	Inside Temp	Dif in Temp	Time P.M.	Inside Temp	Dif in Temp	Time P.M.	Inside Temp	Dif in Temp	Time P.M.	Inside Temp	Dif in Temp
300	Office of Dean	4290	195	44.7	53.3		62.9	116.2	7:10	79	66.4	9:10	79.2	61.2	11:10	80	56.7	1:10	80	53	3:10	77	50	5:10	79	53
301	Faculty Library	9843	450	89.3	40	16		56		66	53.4		64	46		68.5	45.2		78.8	51.8		69.5	42.5		68	42
302	Faculty Parlor	9843	450	89.3	40	16	62.9	118.9	7:11	69.8	57.2	9:11	71.6	52.6	11:11	76.6	53.3	1:11	80.2	53.2	3:11	71.6	44.6	5:11	77	51
303	C.E. Seminary	5100	300	76	30	10	41.2	81.2		80.6	68		63	45		66.6	43.3		68	41		65.8	38.8		80.6	54.6
304	M.E. Seminary	5100	300	76	30	10	41.2	81.2	7:12	66	53.4	9:12	64	46	11:12	68.5	45.2	1:12	73	46	3:12	69.5	42.5	5:12	68	42
305	M.E. Drawing Rm	12600	945	187.5	43.2	36.5	170.2	249.9		74.8	62.2		80.6	62.6		86	62.7		89.1	62.1		89.2	62.2		86	60
306	M.E. Study	39685	217.5	31.2		10	46.4	56.4	7:13	70.8	58.2	9:13	73	55	11:13	76.6	53.3	1:13	76.6	49.6	3:13	79.2	52.2	5:13	77	51
307	M.E. Study	2780	195	62.5		10	46.4	56.4		71.6	59		75.2	57.2		74.4	51.1		80.6	53.6		77.4	50.4		82.4	56.4
308	M.E. Class Rm	84685	688.7	126.2	33	26	108.4	167.4	7:14	61.8	49.2	9:14	64.4	46.4	11:14	71.6	48.3	1:14	74.2	47.2	3:14	77	50	5:14	75.8	49.8
309	M.E. Drawing Rm	20700	1395	342.5	76.7	28.4	221	326		72.6	60		75.2	57.2		77.4	54.1		81	54		82.4	55.4		77	51
310	Office M.E. Dept	2780	195	63.5		10	46.4	56.4	7:15	66.2	53.6	9:15	65.8	47.8	11:15	67.2	43.9	1:15	76	49	3:15	74.2	47.2	5:15	77	51
312	M.E. Drawing Rm	6300	315	93.7	33.3	17	56.7	107		68	55.4		66.2	48.2		70.6	57.3		76	49		76	49		80.2	54.2
312A	M.E. Study	4200	510	93.7	53.3		54.2	107.5	7:16	68	55.4	9:16	66.2	48.2	11:16	70.6	57.3	1:16	76	49	3:16	76	49	5:16	80.2	54.2
313	M.E. Seminary	56002	120	31.2		11.5	41.2	52.7		73	60.4		74.2	56.2		76.2	62.9		77	50		77.4	50.4		78.8	52.8
314	M.E. Cabinet	10500	570	125	36.7	26	92.8	155.5	7:17	69.8	57.2	9:17	68	50	11:17	73	49.7	1:17	76.6	49.6	3:17	77.8	50.8	5:17	76	50
316	Profs Toilet	2400	150	31.4		11.3	28.4	39.7		69.8	57.2		69.8	57.2		72.9	49.6		77.2	50.2		77	50		77.8	51.8
317	Physics Study	33495	203	44.7		11.2	69.6	80.8	7:18	69.8	57.2	9:18	72.4	54.4	11:18	73.4	50.1	1:18	77	50	3:18	77	50	5:18	78.8	52.8
318	Physics Cabinet	8160	210	44.7	~~240~~	11.2	69.6	80.6		59	46.4		60.8	42.8		69	53.7		76	49		78.8	51.8		80.6	54.6
319	Physics Lab	62268	3090	732.5	240	144	278.6	662.6	7:19	71.6	59	9:19	74.8	56.8	11:19	64	53.7	1:19	76	49	3:19	78.8	51.8	5:19	80.6	54.6
	Corridor	51360	600	152.5	300	31		331		68.4	55.8		69.8	51.8		71.5	58.2		74.8	47.8		75.4	48.4		76	50
	Total or Average	239610.7	11,119.2	2536.5	996.2	435.9	1538	2983.3		69.82	57.22		69.81	57.21		72.93	49.63		77.2	50.2		76.31	49.31		77.84	51.84

Table No. 3

r. from 7 A.M. to 6 P.M.

	Inside Temp	Dif. in Temp	Time P.M.	Inside Temp	Dif. in Temp	Time P.M.	Inside Temp	Dif. in Temp
4	74.8	48.3	3:00	68	41	5:00	75.6	49.1
4	71.5	45		66	39		78	51.5
4	84.6	58.1	3:01	79.2	52.2	5:01	84.6	58.1
4	82	56.5		82.4	56.4		80.2	53.7
4	73	46.5	3:02	79.7	52.7	5:02	82	55.5
4	80.2	53.7		80.6	53.6		80.6	54.1
4	73	46.5	3:03	79.7	52.7	5:03	82	55.5
4	73	46.5		79.7	52.7		82	55.5
4	80.6	54.1	3:04	80.6	53.6	5:04	81.6	55.1
4	75.2	48.7		77	50		80.6	54.1
4	75.2	48.7	3:05	76.6	49.6	5:05	84.2	57.7
4								
4	78.4	51.8	3:06	81	54	5:06	82.4	55.8
4	69.8	43.3		75.2	48.2		77	50.5
4	77	50.5	3:07	78.8	51.8	5:07	80.2	53.7
4	82	56.5		79.2	52.2		80.6	54.1
4	75.6	49.1	3:08	77.4	50.4	5:08	78.8	52.3
4	80.6	54.1		80.6	53.6		80.6	54.1
4	80.6	54.1	3:09	81.4	54.4	5:09	82.4	55.8
4	87.8	61.3		87.8	60.8		86	59.5
	78.8	52.3	3:10	80.2	53.2	5:10	80.6	54.1
	77.7	51.2		76.6	49.6		81	54.5

Table No. 4

No of Room	Name of Room	Air Space Cu Ft	Exposed Wall Sq Ft	Glass Surface Sq Ft	Square Feet of Radiation			Temperatures in Degrees Fahr. from 7 AM to 6 P.M.																
					C.I. Radiators	Exposed Pipes	Total Direct	Time A.M.	Inside Temp	Dif. in Temp	Time A.M.	Inside Temp	Dif. in Temp	Time A.M.	Inside Temp	Dif. in Temp	Time P.M.	Inside Temp	Dif. in Temp	Time P.M.	Inside Temp	Dif. in Temp	Time P.M.	Inside Temp	Dif. in Temp
400	Library	9856	448	96	112	21.5	133.5	7:00	72.5	60.5	9:00	73.4	56.4	11:00	79.7	56.7	1:00	74.8	48.3	3:00	68	41	5:00	75.6	49.1
401	Study	5474	328	32	56		56		72	60		74	57		76	53		71.5	45		66	39		78	51.5
402	Study	5474	328	32	60		60	7:01	75.2	62.2	9:01	78.8	61.8	11:01	79.2	56.2	1:01	84.6	58.1	3:01	79.2	52.2	5:01	84.6	58.1
403	Study	2520	450	12	44	19	63		71.6	69.6		76.5	59.5		80.2	57.2		82	56.5		82.4	56.4		80.2	53.7
404	Blue Print Rm.	2520	450	12	44	19	63	7:02	73	61	9:02	75	58	11:02	72	49	1:02	73	46.5	3:02	79.7	52.7	5:02	82	55.5
405	Drawing Rm.	13140	1728	20	116	85	201		74.3	62.5		75.2	58.2		77.9	54.9		80.2	53.7		80.6	53.6		80.6	54.1
406	Blue Print Office	6850	908	10	40	52	92	7:03	73	61	9:03	75	58	11:03	72	49	1:03	73	46.5	3:03	79.7	52.7	5:03	82	55.5
406A	Studio	6058	752	10	60	15.5	75.5		73	61		75	58		72	49		73	46.5		79.7	52.7		82	55.5
407	Drawing Rm.	20378	2300	20	148	68	216	7:04	72.5	60.5	9:04	74.9	57.9	11:04	78.2	55.2	1:04	80.6	54.1	3:04	80.6	53.6	5:04	81.6	55.1
408	Drawing Rm.	20328	2300	20	152	68	220		66.2	54.2		68	51		72.5	49.5		75.2	48.7		77	50		80.6	54.1
413	Toilet	4176	112	12.2	26	9	35	7:05	75.2	63.2	9:05	73.4	56.4	11:05	73.7	50.7	1:05	75.2	48.7	3:05	76.6	49.6	5:05	84.2	57.7
416	Store Room	2016	112	12.2	12	9	21																		
417	Study	3258	196	14.5	36	9	45	7:06	73.4	61.4	9:06	74.9	57.9	11:06	78.8	55.8	1:06	78.4	57.8	3:06	81	54	5:06	82.4	55.8
418	Lecture Rm.	7666	196	14.5	44	5	49		69.8	57.8		71.1	54.1		70.2	47.2		69.8	43.3		75.2	48.2		77	50.5
420	Class Rm.	6048	308	25.4	80	10	90	7:07	70.7	58.7	9:06	71.1	54.1	11:07	75.2	52.2	1:07	77	50.5	3:07	78.8	51.8	5:07	80.2	53.7
421	Arch. Museum	13608	616	53.4	144	20.7	164.7		69.8	57.8		72.5	55.5		78.8	55.8		82	56.5		79.2	52.2		80.6	54.1
422	Class Room	7576	280	28	80	10	90	7:08	73.4	61.4	9:08	70.7	53.7	11:08	73.4	50.4	1:08	75.6	49.1	3:08	77.4	50.4	5:08	78.8	52.3
423	Study	8736	700	56	96	17	113		78.8	66.8		78.8	61.8		78.8	55.8		80.6	54.1		80.6	53.6		80.6	54.1
424	Class Room	8736	700	56	96	17	113	7:09	78.4	66.4	9:09	75.2	58.2	11:09	78.4	55.4	1:09	80.6	54.1	3:09	81.4	54.4	5:09	82.4	55.8
425	Study	2688	168	14	28		28		81.5	69.5		79.7	62.7		81.5	58.5		87.8	61.3		87.8	60.8		86	59.5
	Corridor	41792	480	378	192	124	316	7:10	77.4	65.4	9:10	73.5	56.5	11:10	77.4	54.4	1:10	78.8	52.3	3:10	80.2	53.2	5:10	80.6	54.1
	Total or Average	199098	13850	578.7	1666	578.7	2245.7		73.5	61.5		74.3	57.3		76.3	53.3		77.7	57.2		76.6	49.6		81	54.5

Table No. 4

No. of Floor	Air Space Cu. Ft.	F
1	163776	
2	224224	
3	239610	
4	119098	
Total	746710	
Average		
Time		
Steam Temperature		
Average Dif. Steam Inside Temp		
Pounds Condensation		
Condensation per 1000# Rad. per 2 hours		
Condensation per sq. ft. per hour		

No of Floor	Air Space Cu. Ft.	Exposed Wall Sq. Ft.	Glass Surface Sq. Ft.	Square Feet of Radiation				Average Inside Temperatures				
				C.I. Radiators	Exposed Pipes	W.I Radiators	Total Direct	7 A.M. to 9 P.M.	9 A.M. to 11 P.M.	11 A.M. to 1 P.M	1 P.M to 3 P.M.	3 P.M. to 5 P.M.
1	163776	7690	1354	2093	270.5		2364.5	65.7	67	68.9	70.1	72
2	224224	10899	2469	1147.5	367.2	1619.2	3133.9	66	68.1	71.7	73.9	74.5
3	239610	11119	2536	996.9	435.9	1538	2970	69.8	69.8	72.9	76.2	76.3
4	119098	13850	928	1666	578.7		2245.7	73.5	74.3	76.3	77.6	76.6
Total	746710	43558	7288	5908.7	1652.3	3157	10714	275	279.2	289.8	297.8	299.4
Average								68.7	69.8	72.4	74.4	74.8

Time	7-9	9-11	11-1	1-3	3-5
Steam Temperature	222.4	222.8	223	223.5	224
Average Dif. Steam Inside Temp	153.7	153	150.6	148.1	149.2
Pounds Condensation	6703	6615	6619	6282	6289
Condensation per 1000# Rad. per 2 hours	625.6	617.4	617.8	586.3	587
Condensation per sq. ft. per hour	.3128	.3087	.3089	.2931	.2935

Average Difference in Temperatures

No of Floor	7 A.M to 9 A.M.	9 A.M. to 11 A.M.	11 A.M. to 1 P.M.	1 P.M. to 3 P.M	3 P.M to 5 P.M.
1	52.7	47.5	44.4	42.6	45
2	53.5	49.6	47.7	46.9	47.5
3	57.2	57.2	49.6	50.2	49.3
4	61.5	57.3	53.2	51.1	49.6
Total	224.9	211.6	194.9	190.8	191.4
Average	56.2	52.9	48.7	47.7	47.8

Table No. 5

Gla ALUE FOUND IN TABLE.

Surf

Table No. 6.

Sq	160	165	170	175	180	185	190	195	200
4	10.7	11.0	11.3	11.6	11.9	12.2	12.5	12.8	13.1
6	11.2	11.5	11.8	12.1	12.4	12.7	13.0	13.3	13.6
8	11.7	12.0	12.3	12.6	12.9	13.2	13.5	13.8	14.1
1	12.2	12.5	12.8	13.1	13.4	13.7	14.0	14.3	14.6
1	12.7	13.0	13.3	13.6	13.9	13.2	14.5	14.8	15.1
1	13.2	13.5	13.8	14.1	14.4	14.7	15.0	15.3	15.6
1	13.7	14.0	14.3	14.6	14.9	15.2	15.5	15.8	16.1
1	14.2	14.5	14.8	15.1	15.4	15.7	16.0	16.3	16.6
2	14.7	15.0	15.3	15.6	15.9	16.2	16.5	16.8	17.1
2	15.2	15.5	15.8	16.1	16.4	16.7	17.0	17.3	17.6
2	15.7	16.0	16.3	16.6	16.9	17.2	17.5	17.8	18.1
2	16.2	16.5	16.8	17.1	17.4	17.7	18.0	18.3	18.6
2	16.7	17.0	17.3	17.6	17.9	18.2	18.5	18.8	19.1
3	17.2	17.5	17.8	18.1	18.4	18.7	19.0	19.3	19.6
3	17.7	18.0	18.3	18.6	18.9	19.2	19.5	19.8	20.1
3	18.2	18.5	18.8	19.1	19.4	19.7	20.0	20.3	20.6
3	18.7	19.0	19.3	19.6	19.9	20.2	20.5	20.8	21.1
3	19.2	19.5	19.8	20.1	20.4	20.7	21.0	21.3	21.6
4	19.7	20.0	20.3	20.6	20.9	21.2	21.5	21.8	22.1
4	20.2	20.5	20.8	21.1	21.4	21.7	22.0	22.3	22.6
4	20.7	21.0	21.3	21.6	21.9	22.2	22.5	22.8	23.1
4	21.2	21.5	21.8	22.1	22.4	22.7	23.0	23.3	23.6
5	21.7	22.0	22.3	22.6	22.9	22.2	23.5	23.8	24.1
5	22.2	22.5	22.8	23.1	23.4	23.7	24.0	24.3	24.6
5	22.7	23.0	23.3	23.6	23.9	24.2	24.5	24.8	25.1
5	23.2	23.5	23.8	24.1	24.4	24.7	25.0	25.3	25.6

HEATING SURFACE REQUIRED FOR LOW PRESSURE STEAM HEATING R = 01 C + K K = VALUE FOUND IN TABLE

Table No 6

Glass Surface Sq Ft	Exposed Wall Surface. Sq. Ft																														
	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200
4	4.1	4.4	4.7	5.0	5.3	5.6	5.9	6.2	6.5	6.8	7.1	7.4	7.7	8.0	8.3	8.6	8.9	9.2	9.5	9.8	10.1	10.4	10.7	11.0	11.3	11.6	11.9	12.2	12.5	12.8	13.1
6	4.6	4.9	5.2	5.5	5.8	6.1	6.4	6.7	7.0	7.3	7.6	7.9	8.2	8.5	8.8	9.1	9.4	9.7	10.0	10.3	10.6	10.9	11.2	11.5	11.8	12.1	12.4	12.7	13.0	13.3	13.6
8	5.1	5.4	5.7	6.0	6.3	6.6	6.9	7.2	7.5	7.8	8.1	8.4	8.7	9.0	9.3	9.6	9.9	10.2	10.5	10.8	11.1	11.4	11.7	12.0	12.3	12.6	12.9	13.2	13.5	13.8	14.1
10	5.6	5.9	6.2	6.5	6.8	7.1	7.4	7.7	8.0	8.3	8.6	8.9	9.2	9.5	9.8	10.1	10.4	10.7	11.0	11.3	11.6	11.9	12.2	12.5	12.8	13.1	13.4	13.7	14.0	14.3	14.6
12	6.1	6.4	6.7	7.0	7.3	7.6	7.9	8.2	8.5	8.8	9.1	9.4	9.7	10.0	10.3	10.6	10.9	11.2	11.5	11.8	12.1	12.4	12.7	13.0	13.3	13.6	13.9	13.2	14.5	14.8	15.1
14	6.6	6.9	7.2	7.5	7.8	8.1	8.4	8.7	9.0	9.3	9.6	9.9	10.2	10.5	10.8	11.1	11.4	11.7	12.0	12.3	12.6	12.9	13.2	13.5	13.8	14.1	14.4	14.7	15.0	15.3	15.6
16	7.1	7.4	7.7	8.0	8.3	8.6	8.9	9.2	9.5	9.8	10.1	10.4	10.7	11.0	11.3	11.6	11.9	12.2	12.5	12.8	13.1	13.4	13.7	14.0	14.3	14.6	14.9	15.2	15.5	15.8	16.1
18	7.6	7.9	8.2	8.5	8.8	9.1	9.4	9.7	10.0	10.3	10.6	10.9	11.2	11.5	11.8	12.1	12.4	12.7	13.0	13.3	13.6	13.9	14.2	14.5	14.8	15.1	15.4	15.7	16.0	16.3	16.6
20	8.1	8.4	8.7	9.0	9.3	9.6	9.9	10.2	10.5	10.8	11.1	11.4	11.7	12.0	12.3	12.6	12.9	13.2	13.5	13.8	14.1	14.4	14.7	15.0	15.3	15.6	15.9	16.2	16.5	16.8	17.1
22	8.6	8.9	9.2	9.5	9.8	10.1	10.4	10.7	11.0	11.3	11.6	11.9	12.2	12.5	12.8	13.1	13.4	13.7	14.0	14.3	14.6	14.9	15.2	15.5	15.8	16.1	16.4	16.7	17.0	17.3	17.6
24	9.1	9.4	9.7	10.0	10.3	10.6	10.9	11.2	11.5	11.8	12.1	12.4	12.7	13.0	13.3	13.6	13.9	14.2	4.5	14.8	15.1	15.4	15.7	16.0	16.3	16.6	16.9	17.2	17.5	17.8	18.1
26	9.6	9.9	10.2	10.5	10.8	11.1	11.4	11.7	12.0	12.3	12.6	12.9	13.2	13.5	13.8	14.1	14.4	14.7	15.0	15.3	15.6	15.9	16.2	16.5	16.8	17.1	17.4	17.7	18.0	18.3	18.6
28	10.1	10.4	10.7	11.0	11.3	11.6	11.9	12.2	12.5	12.8	13.1	13.4	13.7	14.0	14.3	14.6	14.9	15.2	15.5	15.8	16.1	16.4	16.7	17.0	17.3	17.6	17.9	18.2	18.5	18.8	19.1
30	10.6	10.9	11.2	11.5	11.8	12.1	12.4	12.7	13.0	13.3	13.6	13.9	14.2	14.5	14.8	15.1	15.4	15.7	16.0	16.3	6.6	16.9	17.2	17.5	17.8	18.1	18.4	18.7	19.0	19.3	19.6
32	11.1	11.4	11.7	12.0	12.3	12.6	12.9	13.2	13.5	13.8	14.1	14.4	14.7	15.0	15.3	15.6	15.9	16.2	16.5	16.8	17.1	17.4	17.7	18.0	18.3	18.6	18.9	19.2	19.5	19.8	20.1
34	11.6	11.9	12.2	12.5	12.8	13.1	13.4	13.7	14.0	14.3	14.6	14.9	15.2	15.5	15.8	16.1	16.4	16.7	17.0	17.3	17.6	17.9	18.2	18.5	18.8	19.1	19.4	19.7	20.0	20.3	20.6
36	12.1	12.4	12.7	13.0	13.3	13.6	13.9	14.2	14.5	14.8	15.1	15.4	15.7	16.0	16.3	16.6	16.9	17.2	17.5	17.8	18.1	18.4	18.7	19.0	19.3	19.6	19.9	20.2	20.5	20.8	21.1
38	12.6	12.9	13.2	13.5	13.8	14.1	14.4	14.7	15.0	15.3	15.6	15.9	16.2	16.5	16.8	17.1	17.4	17.7	18.0	18.3	18.6	18.9	19.2	19.5	19.8	20.1	20.4	20.7	21.0	21.3	21.6
40	13.1	13.4	13.7	14.0	14.3	14.6	14.9	15.2	15.5	15.8	16.1	16.4	16.7	17.0	17.3	17.6	17.9	18.2	18.5	18.8	19.1	19.4	19.7	20.0	20.3	20.6	20.9	21.2	21.5	21.8	22.1
42	13.6	13.9	14.2	14.5	14.8	15.1	15.4	15.7	16.0	16.3	16.6	16.9	17.2	17.5	17.8	18.1	18.4	18.7	19.0	19.3	19.6	19.9	20.2	20.5	20.8	21.1	21.4	21.7	22.0	22.3	22.6
46	14.1	14.4	14.7	15.0	15.3	15.6	15.9	16.2	16.5	16.8	17.1	17.4	17.7	18.0	18.3	18.6	18.9	19.2	19.5	19.8	20.1	20.4	20.7	21.0	21.3	21.6	21.9	22.2	22.5	22.8	23.1
48	14.6	14.9	15.2	15.5	15.8	16.1	16.4	16.7	17.0	17.3	17.6	17.9	18.2	18.5	18.8	19.1	19.4	19.7	20.0	20.3	20.6	20.9	21.2	21.5	21.8	22.1	22.4	22.7	23.0	23.3	23.6
50	15.1	15.4	15.7	16.0	16.3	16.6	16.9	17.2	17.5	17.8	18.1	18.4	18.7	19.0	19.3	19.6	19.9	20.2	20.5	20.8	21.1	21.4	21.7	22.0	22.3	22.6	22.9	22.2	23.5	23.8	24.1
52	15.6	15.9	16.2	16.5	16.8	17.1	17.4	17.7	18.0	18.3	18.6	18.9	19.2	19.5	19.8	20.1	20.4	20.7	21.0	21.3	21.6	21.9	22.2	22.5	22.8	23.1	23.4	23.7	24.0	24.3	24.6
54	16.1	16.4	16.7	17.0	17.3	17.6	17.9	18.2	18.5	18.8	19.1	19.4	19.7	20.0	20.3	20.6	21.9	21.2	21.5	21.8	22.1	22.4	22.7	23.0	23.3	23.6	23.9	24.2	24.5	24.8	25.1
56	16.6	16.9	17.2	17.5	17.8	18.1	18.4	18.7	19.0	19.3	19.6	19.9	20.2	20.5	20.8	21.1	22.4	21.7	22.0	22.3	22.6	22.9	23.2	23.5	23.8	24.1	24.4	24.7	25.0	25.3	25.6

TAKEN FROM MILLS'

"THE WARMING AND VENTILATION OF BUILDINGS"

Heating Surfaces Required in Radiators, Low Pressure Steam and Water Circulation, at Similar Temperatures and Average Conditions.

One square foot of heating surface = 2 square feet of glass, 20 square feet of wall, and 200 cubic feet of space.

Glass	Outside Wall, Hundreds of Square Feet.																			
Sq.Ft.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
10	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105
20	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110
30	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115
40	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120
50	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125
60	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130
70	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135
80	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140
90	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145
100	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150
110	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155
120	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160
130	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165
140	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170
150	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175
160	85	90	95	100	*105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180
170	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185
180	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190
190	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195
200	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200
210	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205
220	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210
230	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215
240	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220
250	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225
260	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230
270	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235
280	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235	240
290	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235	240	245
300	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235	240	245	250
310	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235	240	245	250	255
320	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235	240	245	250	255	260
330	170	175	180	185	190	195	200	205	210	215	220	225	230	235	240	245	250	255	260	265
340	175	180	185	190	195	200	205	210	215	220	225	230	235	240	245	250	255	260	265	270
350	180	185	190	195	200	205	210	215	220	225	230	235	240	245	250	255	260	265	270	275
360	185	190	195	200	205	210	215	220	225	230	235	240	245	250	255	260	265	270	275	280
370	190	195	200	205	210	215	220	225	230	235	240	245	250	255	260	265	270	275	280	285
380	195	200	205	210	215	220	225	230	235	240	245	250	255	260	265	270	275	280	285	290
390	200	205	210	215	220	225	230	235	240	245	250	255	260	265	270	275	280	285	290	295
400	205	210	215	220	225	230	235	240	245	250	255	260	265	270	275	280	285	290	295	300
410	210	215	220	225	230	235	240	245	250	255	260	265	270	275	280	285	290	295	300	305
420	215	220	225	230	235	240	245	250	255	260	265	270	275	280	285	290	295	300	305	
430	220	225	230	235	240	245	250	255	260	265	270	275	280	285	290	295	300	305		
440	225	230	235	240	245	250	255	260	265	270	275	280	285	290	295	300	305			
450	230	235	240	245	250	255	260	265	270	275	280	285	290	295	300	305				
460	235	240	245	250	255	260	265	270	275	280	285	290	295	300	305					
470	240	245	250	255	260	265	270	275	280	285	290	295	300	305						
480	245	250	255	260	265	270	275	280	285	290	295	300	305							
490	250	255	260	265	270	275	280	285	290	295	300	305								
500	255	260	265	270	275	280	285	290	295	300	305									
510	260	265	270	275	280	285	290	295	300	305										
520	265	270	275	280	285	290	295	300	305											
530	270	275	280	285	290	295	300	305												
540	275	280	285	290	295	300	305													
550	280	285	290	295	300	305														
560	285	290	295	300	305															
570	290	295	300	305																
580	295	300	305																	
590	300	305																		
600	305																			

RULE.

Take the number corresponding to the amount of glass and outside wall (Table 20). The number opposite this (Table 21) in the column denoting the cubical contents of the room is the *radiating surface in square feet.*

Example I. Corner room 30 × 30 × 11 = 9900 cubic feet. Two exposed sides, 500 square feet of wall, 160 square feet of glass. Demand for glass and wall (Table 20) = 105*. Radiating surface (Table 21) = 155†. Proportion of radiating surface to space warmed (Table 21 = 1 : 65.‡

Example II. Room with *one exposed side.* Contents, 5000 cubic feet; 200 square feet of exposed wall; 50 square feet of glass. Demand for wall and glass (Table 20) = 35. Radiating surface (Table 21) = 60 square feet. Proportion of radiating surface to space warmed (Table 21) = (approximately) 1 : 85.

Combined Demand in Radiators for Rooms and Offices with Different Exposures. *

Glass and Wall from Table No. 20. Space Warmed, Air to change each hour, Table No. 21.

Based on steam conditions and pressures 5 to 10 lbs.

Radiation Required by Table 20.	THOUSANDS OF CUBIC FEET IN THE ROOMS.																		Radiating Surface to Space Warmed.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	
15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	1:170
20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	1:160
25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	1:150
30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	
35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	1:140
40	45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	
45	50	55	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	1:130
50	...	60	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	
55	...	65	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	1:120
60	...	70	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	
65	...	75	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	1:115
70	...	80	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	1:110
75	...	85	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	
80	...	90	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	1:105
85	...	95	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	
90	...	100	105	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	1:100
95	...	...	110	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	
100	...	...	115	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	1:95
105	...	...	120	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	
110	...	...	125	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	1:90
115	...	...	130	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	
120	...	...	135	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	1:85
125	...	...	140	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	
130	...	...	145	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	
135	...	...	150	155	160	165	170	175	180	185	190	195	200	205	210	215	220	225	1:80
140	...	...	...	160	165	170	175	180	185	190	195	200	205	210	215	220	225	230	
145	...	...	...	165	170	175	180	185	190	195	200	205	210	215	220	225	230	235	
150	...	...	...	170	175	180	185	190	195	200	205	210	215	220	225	230	235	240	1:75
155	...	...	...	175	180	185	190	195	200	205	210	215	220	225	230	235	240	245	
160	...	...	...	180	185	190	195	200	205	210	215	220	225	230	235	240	245	250	
165	...	...	...	185	190	195	200	205	210	215	220	225	230	235	240	245	250	255	1:70
170	...	...	...	190	195	200	205	210	215	220	225	230	235	240	245	250	255	260	
175	...	...	...	195	200	205	210	215	220	225	230	235	240	245	250	255	260	265	
180	...	...	...	200	205	210	215	220	225	230	235	240	245	250	255	260	265	270	
185	...	...	...	...	210	215	220	225	230	235	240	245	250	255	260	265	270	275	1:65
190	...	...	...	...	215	220	225	230	235	240	245	250	255	260	265	270	275	280	
195	...	...	...	...	220	225	230	235	240	245	250	255	260	265	270	275	280	285	
200	...	...	...	...	225	230	235	240	245	250	255	260	265	270	275	280	285	290	
205	...	...	...	...	230	235	240	245	250	255	260	265	270	275	280	285	290	295	
210	...	...	...	...	235	240	245	250	255	260	265	270	275	280	285	290	295	300	1:60
215	...	...	...	...	240	245	250	255	260	265	270	275	280	285	290	295	300	305	
220	...	...	...	...	245	250	255	260	265	270	275	280	285	290	295	300	305	310	
225	...	...	...	...	250	255	260	265	270	275	280	285	290	295	300	305	310	315	
230	...	...	...	...	...	260	265	270	275	280	285	290	295	300	305	310	315	320	
235	...	...	...	...	...	265	270	275	280	285	290	295	300	305	310	315	320	325	1:55
240	...	...	...	...	...	270	275	280	285	290	295	300	305	310	315	320	325	330	
245	...	...	...	...	...	275	280	285	290	295	300	305	310	315	320	325	330	335	
250	...	...	...	...	...	280	285	290	295	300	305	310	315	320	325	330	335	340	
255	...	...	...	...	...	285	290	295	300	305	310	315	320	325	330	335	340	345	
260	...	...	...	...	...	290	295	300	305	310	315	320	325	330	335	340	345	350	
265	...	...	...	...	...	295	300	305	310	315	320	325	330	335	340	345	350	355	
270	...	...	...	...	...	300	305	310	315	320	325	330	335	340	345	350	355	360	1:50
275	...	...	...	...	...	...	310	315	320	325	330	335	340	345	350	355	360	365	
280	...	...	...	...	...	...	315	320	325	330	335	340	345	350	355	360	365	370	
285	...	...	...	...	...	...	320	325	330	335	340	345	350	355	360	365	370	375	
290	...	...	...	...	...	...	325	330	335	340	345	350	355	360	365	370	375	380	
295	...	...	...	...	...	...	330	335	340	345	350	355	360	365	370	375	380	385	
300	...	...	...	...	...	...	335	340	345	350	355	360	365	370	375	380	385	390	
305	...	...	...	...	...	...	340	345	350	355	360	365	370	375	380	385	390	395	
							1:20		1:25		1:30		1:35		1:40		1:45		

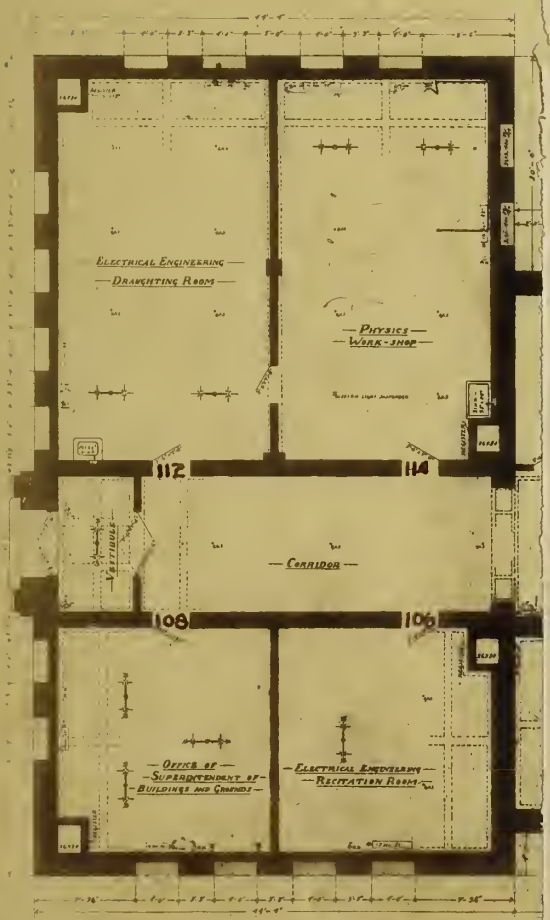
* For mild water circulation (average temperature 180°), add one third = 33 per cent.

* For *stores* (15,000 to 20,000 cubic feet), deduct one third = 33 per cent.

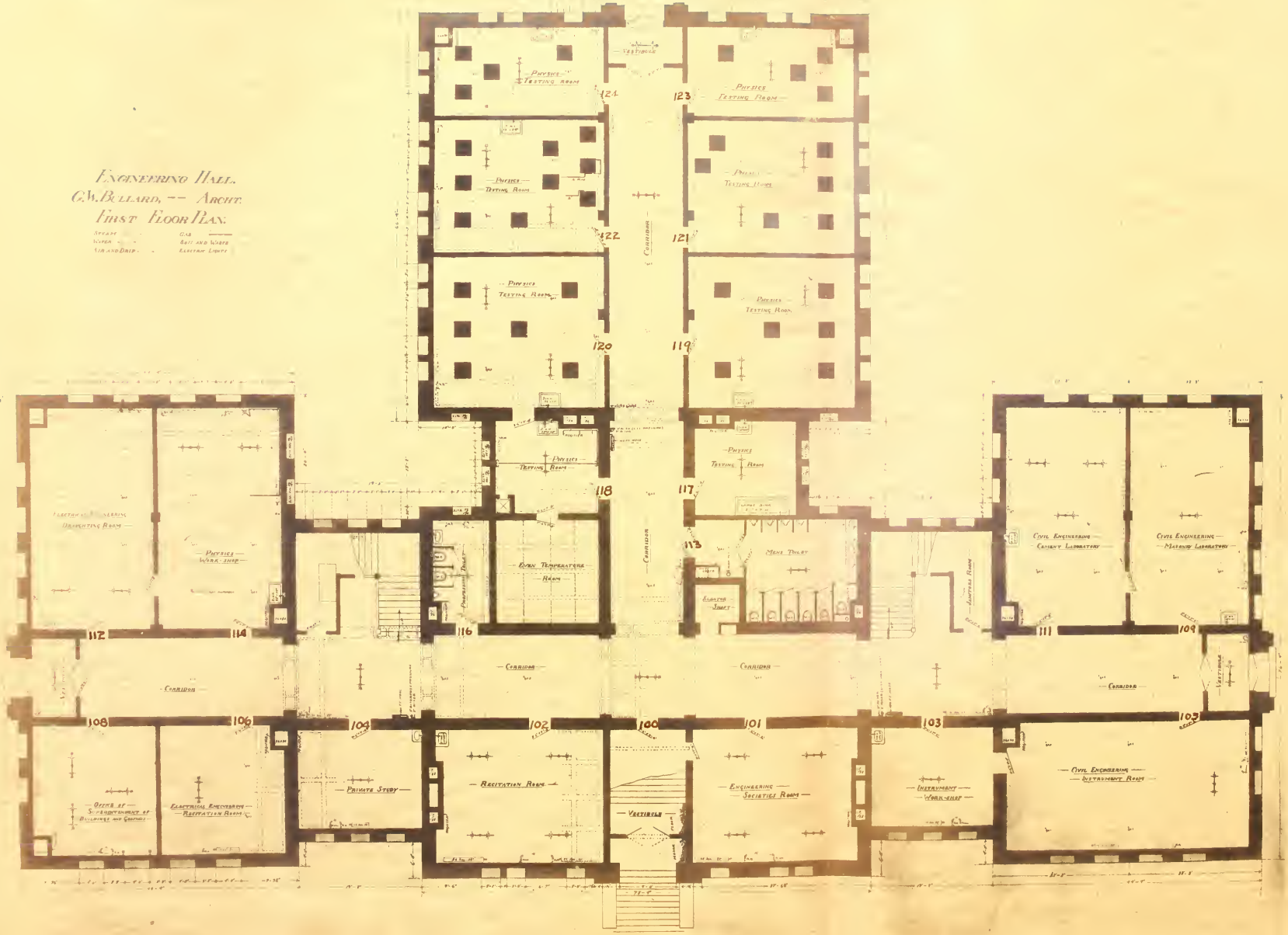
ENGINEERING HALL

Engineering Hall.
G. W. Bullard, -- Archt.
First Floor Plan.

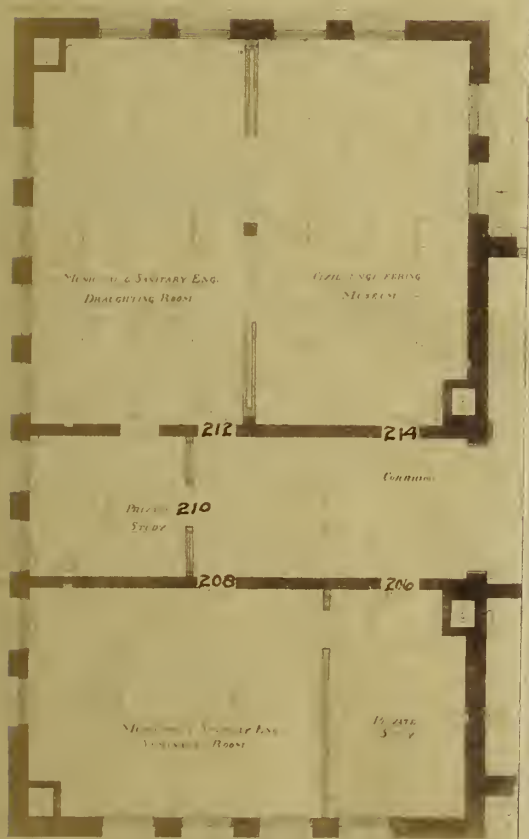
Steam ——— Gas ———
Water ——— Soil and Waste ———
Air and Drip — — Electric Lights

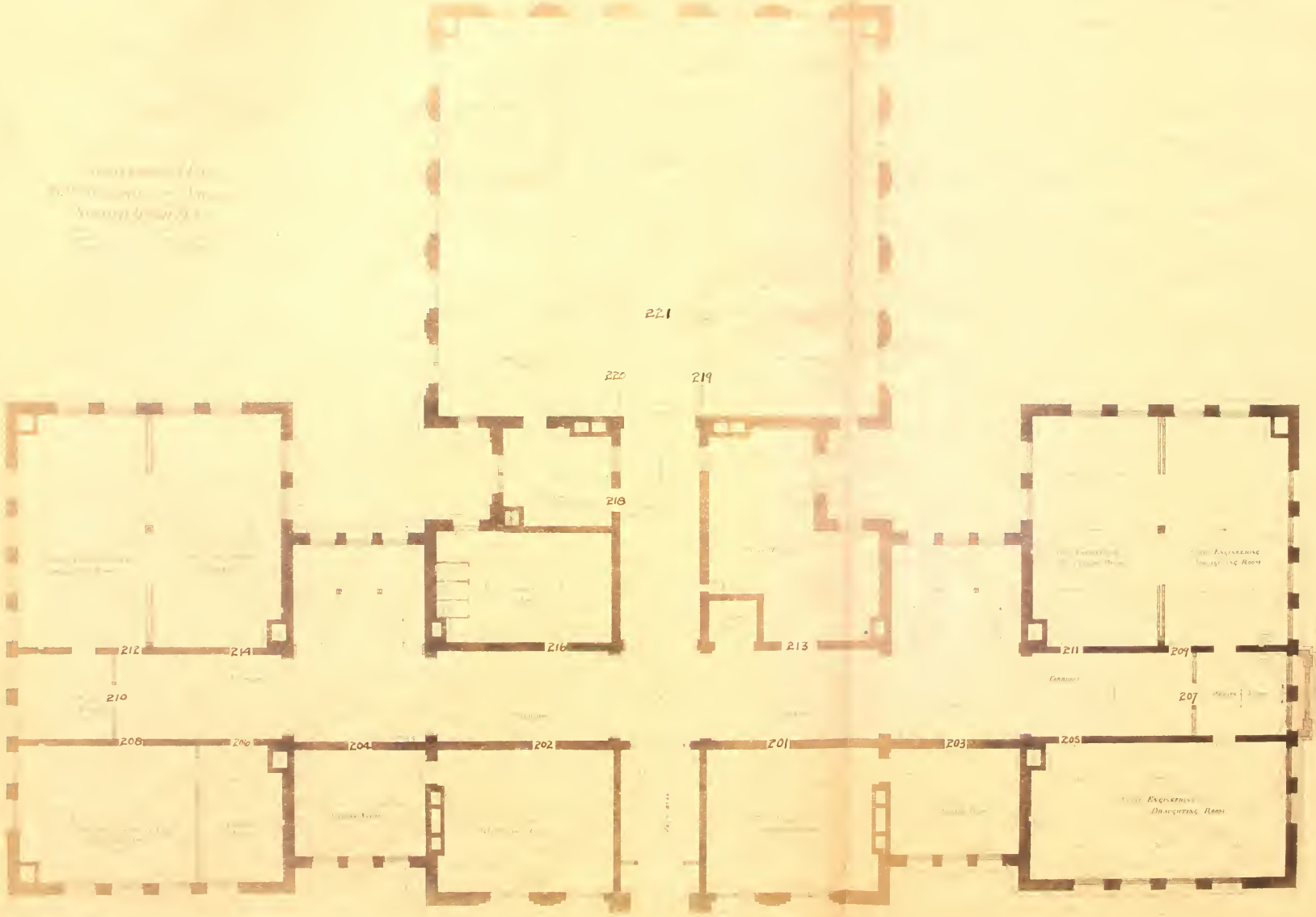


ENGINEERING HALL.
G.W. BULLARD, -- ARCHT.
FIRST FLOOR PLAN.



Engineering Hall.
G.W. Bullard, -- Archt.
Second Floor Plan.




221
220
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212
214
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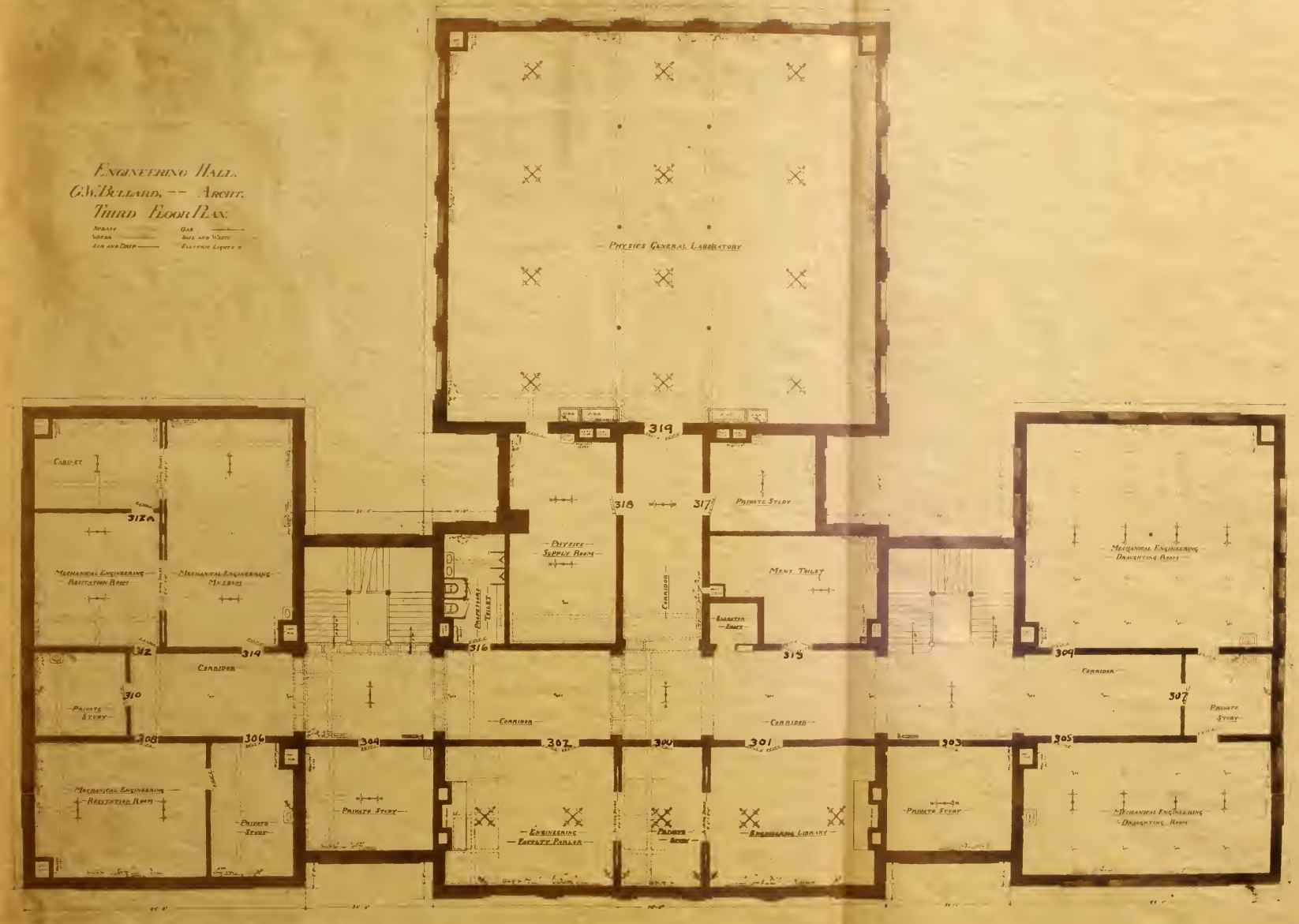
205

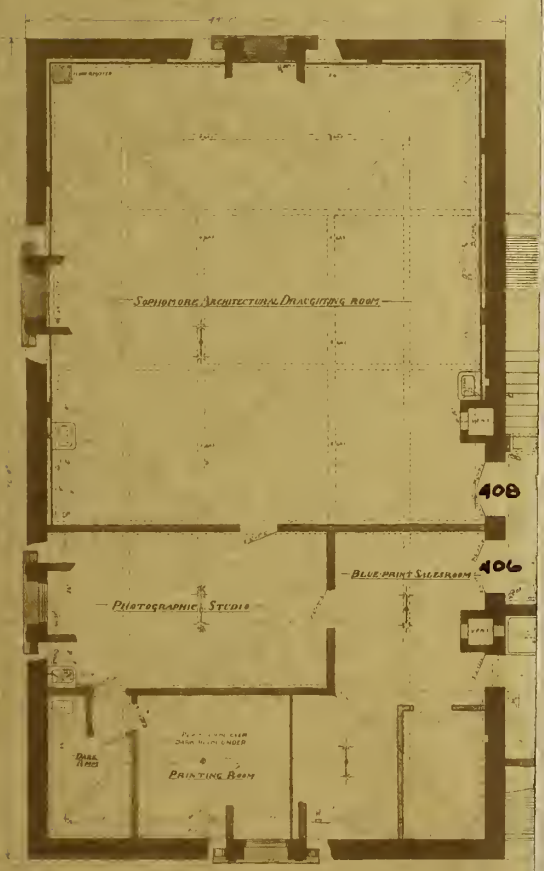
Engineering Hall.
G.W. Bullard, -- Archt.
Third Floor Plan.

Steam ——— Gas ———
Water ——— Soil and Waste ———
Air and Drip ——— Electric Lights ———


ENGINEERING HALL.
G.W. BELLARD, -- ARCHT.
THIRD FLOOR PLAN.
SCALE
SUPPLY
AIR AND DRIP
GAS
SOIL AND WASTE
ELECTRIC LIGHTS
PHYSICS GENERAL LABORATORY
319
318
317
312A
312
314
316
315
310
308
306
304
307
300
301
303
305
309
307
CABINET
PRIVATE STUDY
PHYSICS SUPPLY ROOM
MENS TOILET
CORRIDOR
LADIES TOILET
MECHANICAL ENGINEERING RECITATION ROOM
MECHANICAL ENGINEERING MUSEUM
MECHANICAL ENGINEERING DRAUGHTING ROOM
ENGINEERING FACULTY PARLOR
ENGINEERING LIBRARY

Engineering Hall.
G.W. Bullard, -- Archt.
Fourth Floor Plan.

Steam. ——— Gas. ———
Water. ——— Soil and Waste. ———
Air and Drip. ——— Electric Lights. ✕



Engineering Hall.
G.W. Bellamy, — Archt.
Fourth Floor Plan